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Clean Development Mechanism (CDM) after the first commitment period: Assessment of the world's portfolio and the role of Latin America

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A B S T R A C T

The clean Development Mechanism (CDM) represents the main effort to help developing countries develop sustainably and developed countries to reach their emission reductions targets set under the Kyoto Protocol. With the ending of the first commitment period, there is an opportunity to assess the state of the CDM portfolio (2008–2012). This article is the first effort to evaluate the CDM portfolio throughout the first commitment period, as well as the first paper focused on Latin America's CDM portfolio as a whole, concentrating on renewable energy projects. Moreover, a special analysis is performed for Chile, Latin America's third most important CDM country (after Brazil and Mexico), 6th worldwide (after China, India, Korea, Brazil and Mexico) and first in CERs registered among the small countries, an ideal host because of its high political stability, government effectiveness, access to capital and regulatory quality. In addition, a study was performed on 180 renewable energy projects in Latin America, revealing that the additionality assessments performed under the CDM are too subjective, hindering the validation of the projects and their transparency. The main policy implication of this research is to expose the need for a radical change to the succeeding document to the Kyoto Protocol in order to reduce the inequality amongst host countries and ensure that CDM fulfills its sustainable development claim. Some of the proposed measures include establishing uniform benchmarks to be used against similar projects, a thorough validation for declared barriers, simplifying the registering process, and providing international aid for the least developed countries that have historically lacked the ability to participate in the CDM.

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1. Introduction

Anthropogenic climate change, primarily due to the increase in greenhouse gases (GHGs) in the atmosphere, is a phenomenon capable of affecting both human life and the planet's ecology. Even though industrialized countries are responsible for the majority GHG emissions, developing countries' growth in emissions has also been significant [1–4].

Reducing GHG emissions globally is critical to limit the impacts of global warming [5], that is why the United Nations Framework Convention on Climate Change (UNFCCC) [6] was established as an agreement to address the problem of climate change [7]. Its main aim is to stabilize atmospheric concentrations of GHGs, while assuring food, security, adaptation of ecosystems, and sustainable development [8].

The Kyoto Protocol to the UNFCCC was adopted in 1997 as a mechanism to reverse the increase in GHGs emissions. Its main achievement, beyond creating social awareness, is to create legally binding obligations for industrialized countries (referred as Annex I countries) to reduce their emissions of GHGs to an average of 5% below their 1990 levels over the first commitment period from 2008 to 2012 [9–13].

Three flexible mechanisms were established under the Kyoto Protocol to lower the compliance costs for industrialized countries and allow for geographical and temporal flexibility: International Emissions Trading, Joint Implementation, and the Clean Development Mechanism (CDM). The latter allows Annex I countries to invest in projects in non-Annex I countries and receive credits for certified emission reductions (CERs), corresponding to an approved metric tonne of CO_2e reduced [14–18].

CDMs offer the opportunity for developed countries' to reach their emissions targets as economically efficient as possible, and for developing countries to receive international investment. This is realized through CDM's dual objectives of achieving cost effective reductions of GHGs in developed countries and sustainable development in developing countries [8,19–21].

While CDM has contributed to climate change mitigation and offers developing countries an opportunity to participate in the global carbon market by hosting projects, it is widely considered to be imperfect [17]. The major criticisms surrounding CDM include high transaction costs [22,23], the promotion of CDM projects with higher dividends whilst neglecting the pursuit of sustainable development, difficulty testing a project's additionality[1] and unequal distribution of both projects and funding across developing countries [3,19,21].

The objective of this article is to be the first to analyze the world's CDM global distribution of projects with an emphasis in Latin America, taking advantage of the recent end of the first commitment period, and to understand the causes that have led to the current CDM distribution across host countries. Latin America has been an active participant in the mechanism and the first region where all eligible countries have hosted a CDM project [4]. Inside Latin America, Chile will be examined more closely. Amongst Latin America countries, Chile represents an interesting case considering it is the third most active country in CDM in the region, only after giants Brazil and Mexico, the 6th most active worldwide, and has the most registered CERs amongst the small countries. In addition, Chile is one of the main economies in the region, occupying the first place in human development, GDP per capita, life expectancy, and peacefulness. In addition, Chile is characterized by political stability, absence of violence, government effectiveness, access to capital, regulatory quality, rule of law, control of corruption and the lowest murder rate of the region. These characteristic may contribute to the appeal of Chile as a place to develop CDM projects [24–27]. Ultimately, a case study of a sample of renewable energy projects in the region will be analyzed to assess the arguments stipulated for the projects' inclusion into the CDM program (additionality test).

The paper is organized as follows: Section 2 discusses the geographical distribution of projects and different technologies throughout the world. Section 3 describes the specific situation for Latin America and Section 4 for Chile. In Section 5, a case study on renewable CDM projects is carried out, highlighting the arguments provided for the inclusion of the projects under the CDM program. Section 6 concludes the paper.

2. Distribution of CDM projects around the globe

2.1. CDM Portfolio in the world: distribution across different regions

To be eligible to host a CDM project requires the country to ratify the Kyoto Protocol and establish a Designated National Authority (DNA). As of December 8, 2012, 154 non-Annex I countries have ratified the Kyoto Protocol, and of these, 130 have also established a DNA, corresponding to 84% of the total countries. Of all eligible countries, 81 (62%) have hosted a CDM project.

A total of 5193 CDM projects were registered through December 2012, representing 1,115,241.36 kCERs. Of these projects, 4238 are electricity generation projects with a combined installed capacity of 191,204.93 MW. The spread of projects is very wide but from a regional perspective the projects are quite concentrated. The Asia and the Pacific region has the most, with 83% of the total CDM projects, where China and India are the major participants, each with 52% and 19%, respectively, of the region's projects, while Vietnam comes in third place with 3% of them. The region also holds 90% of the electricity generating registered capacity and 86% of the world's total issued CERs. Latin America has the second most CDMs, with 13%, where Brazil and Mexico are the strongest countries, each containing 2% and 1%, respectively of the world's total CDM projects. The Latin American region has 6% of the total generation capacity and has issued 11% of the total carbon credits. It is important to realize that 10 countries with the most registered CDM projects make up more than 90% of the total generation capacity and issued CERs. This illustrates the unequal distribution of projects across qualifying countries. Africa and the

[1] Additionality is one of the eligibility criteria for CDM projects, meaning that emission reductions from a CDM project should be “additional to any that would occur in the absence of such activities” (UNFCCC, 1997).

Middle East are barely represented, the first with 2% of the total CDM projects, and the latter with only 1% (see Fig. 1 and Table 1) [28,29]. The leading CDM countries are also those attracting the most significant proportion of total foreign direct investment (FDI) flows, whereas the poorest nations are unable to attract FDI flows, and consequently CDM projects, as they lack the capacities to be interesting to investors [8,17].

CDM has changed a lot since it started in 2005, when the first project was registered in Brazil. Up until 2009, India showed this highest registry rate for new projects. During the last three years of the first commitment period, China took the lead and registered projects twice as fast as the rest of the world combined and issuing CERs at a rate of almost three times (see Fig. 2).

2.2. CDM spread of project activities

CDM projects are concentrated mainly in two types: renewable energy and methane reduction projects. Of the 5193 registered projects, 71% of them correspond to renewable energy and 17% to methane reduction projects. The scale of emission reductions from these two types of projects is very different. Renewable energy projects are expected to generate between 0.2 and 780 kt CO_2-eq credits/year, reductions of HFC23 and N_2O projects obtain millions of credits per year [8]. The latter offer almost no benefits regarding sustainable development, instead renewable energies offer long term values by increasing energy security, improving air quality, attracting income and generating technology transfer. For these reasons, they are associated with more sustainable development benefits, but they deliver higher cost emission reductions and require more investment in infrastructure [21].

Renewable energy projects concentrate 72% of the total projects generating electricity, with a capacity of 136,790.96 MW, 14% of energy projects are energy efficiency (supply side) projects with 27,303.37 MW, 3% are fuel switching with 24,636.21 MW, and 1% to methane reduction projects with 2430.27 MW. Therefore, the CDM portfolio varies greatly when looking at the number of projects registered, issuance of CERs or projects generating electricity. Table 2 presents the types of projects distributed across regions and Table 3 does the same but for the top 5 countries.

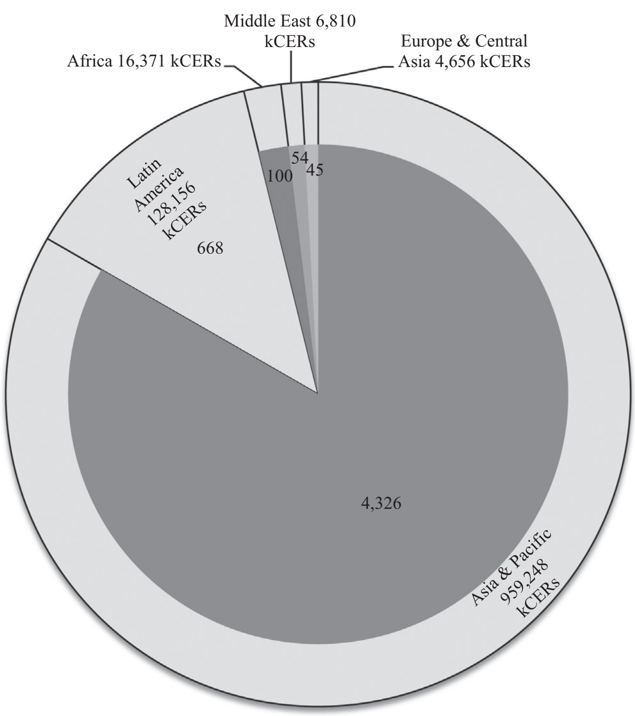

Fig. 1. Geographical Distribution from registered CDM projects.
Data sources: UNEP Risoe and UNFCCC.

2.3. Renewable energy projects

As of December 2012, renewable energy projects represented 72% of the total registered capacity of CDM projects in the world, corresponding to 136,790.05 MW. Of the renewable energy projects, 90% are in the Asia and Pacific, 8% in Latin America, 1% in Europe and Central Asia and 1% in Africa. The Middle East has less than 1% of the renewable energy projects generating electricity within the CDM registry. Wind projects are the most common, with over 70,000 MW of registered capacity, followed by hydroelectricity with over 50,000 MW (see Fig. 3).

2.4. Discussion on the distribution of projects across host countries

Countries with more active participation in the CDM are those with high FDI confidence index [8] and high emission levels. In the FDI index list for 2012 [30], the first three countries correspond to China, India and Brazil, with indexes of 1.87, 1.73 and 1.60, respectively, which are also the developing countries attracting more CDM projects.

The most GHG-emitting developing countries, such as China, India, Indonesia and Vietnam, also have more opportunities for emission reductions and are able to participate more in the CDM and issue more CERs. From the developing countries with the lowest emissions, such as Saint Helena, Niue and Kiribati, none of them have hosted a CDM project, the reason for this being that the majority do not have a DNA. Bhutan is the country with the lowest

Table 1
Issued CERs, projects, capacity and average size for top 10 countries participating in the CDM.
Data sources: UNEP Risoe and UNFCCC.

Country	Issued kCERs	%	No. of projects	%	MW registered	%	Average size (MW)
China	677,608.08	61	2707	52	133,070.17	70	49
India	156,813.10	14	962	19	30,174.59	16	31
South Korea	100,095.19	9	77	1	947.99	0	12
Brazil	76,053.73	7	227	4	4066.33	2	18
Mexico	17,614.05	2	150	3	2155.83	1	14
Chile	10,194.54	1	62	1	1411.64	1	23
Argentina	9365.35	1	30	1	318.00	0	11
Egypt	9281.34	1	11	0	431.60	0	39
Vietnam	7503.29	1	167	3	3732.58	2	22
Indonesia	6119.38	1	93	2	1271.736	1	14
Total 10 countries	**1,070,648.05**	**96**	**4486.00**	**86.00**	**177,580.47**	**93**	**40**
Others	44,593	4	707	14	13,624	7	19
World Total	**1,115,241.36**	**100**	**5193**	**100**	**191,204.93**	**100**	**37**

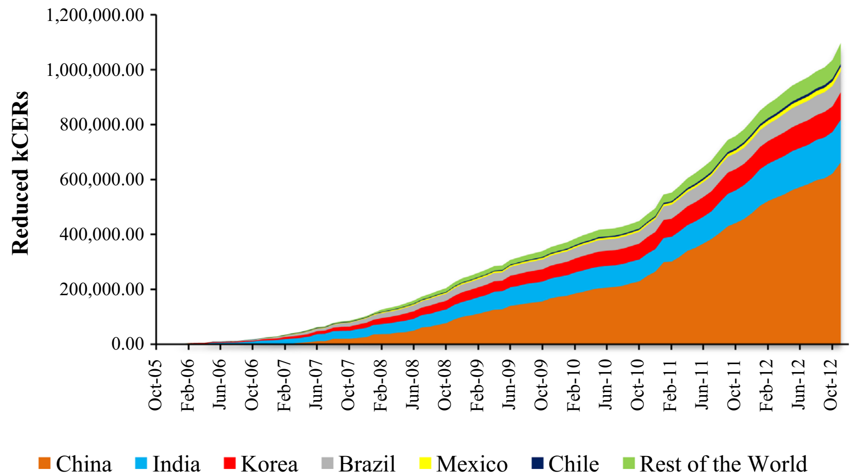

Fig. 2. Temporal Evolution of issued kCERs from top 6 countries.
Data sources: UNEP Risoe and UNFCCC.

Table 2
Different types of projects distributed across the regions.
Data sources: UNEP Risoe and UNFCCC.

Type	Asia and Pacific	%	Latin America	%	Africa	%	Middle East	%	Europe and Central Asia	%	Total	%
Renewable energy	3288	76	305	46	38	38	13	24	15	33	**3659**	71
CH_4 reductions	519	12	294	44	30	30	18	33	16	36	**877**	17
Energy efficiency – supply	275	6	12	2	2	2	4	7	1	2	**294**	6
HFC and N_2O reductions	80	2	15	2	8	8	7	13	7	16	**117**	2
Energy efficiency – demand	97	2	5	1	5	5	3	6	3	7	**113**	2
Fuel switch	49	1	10	1	5	5	9	17	1	2	**74**	1
Sinks	11	0	15	2	12	12	0	0	2	4	**40**	1
Transport	7	0	12	2	0	0	0	0	0	0	**19**	0
Total	**4326**	**100**	**668**	**100**	**100**	**100**	**54**	**100**	**45**	**100**	**5193**	**100**

Table 3
Different types of projects distributed across the top 5 countries.
Data sources: UNEP Risoe and UNFCCC.

Type	China	%	India	%	Brazil	%	Vietnam	%	Mexico	%	Total	% From total in technology
Renewable energy	2254	83	712	74	116	51	142	85	21	14	**3245**	89
CH_4 reductions	192	7	51	5	92	41	23	14	119	79	**447**	54
Energy efficiency – supply	178	7	78	8	4	2	0	0	1	1	**261**	89
HFC and N_2O reductions	47	2	14	1	7	3	0	0	2	1	**70**	60
Energy efficiency – demand	4	0	81	8	0	0	1	1	3	2	**89**	79
Fuel switch	26	1	15	2	6	3	0	0	0	0	**47**	64
Sinks	3	0	7	1	2	1	1	1	0	0	**13**	33
Transport	3	0	4	0	0	0	0	0	4	3	**11**	58
Total	**2707**	**100**	**965**	**100**	**227**	**100**	**167**	**100**	**150**	**100**	**4216**	**81**

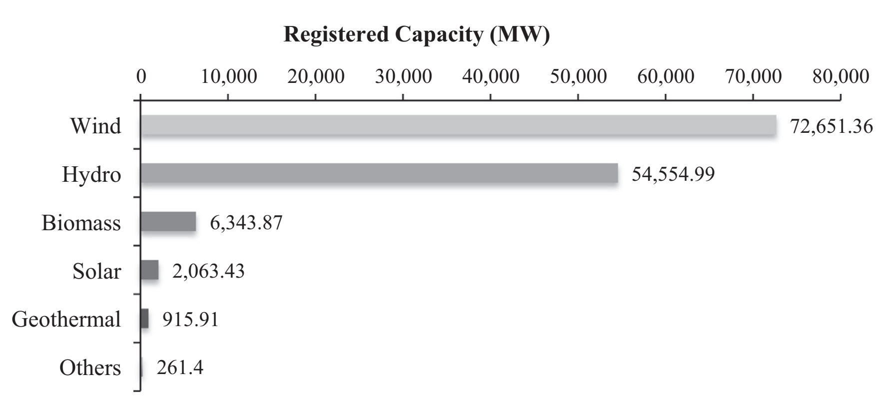

Fig. 3. Registered capacity by type of renewable energy.
Data sources: UNEP Risoe and UNFCCC.

GHG emissions that has also developed CDM projects. For the most active countries, the cases of Vietnam, China and India are interesting to analyze. Vietnam's GDP has grown at an average rate of 7% for the past 15 years, in spite of the global economic slowdown. In addition, Vietnam's energy demand has also grown. In 2009 Vietnam started a program to increase their electricity generation capacity and exploit the CDM program, particularly focusing on renewable energy projects. At the end of the first commitment period, Vietnam occupied one of the top spots in CDM participation, with 85% renewable energy projects [31].

China, the world leader in CDM participation, had a rather slow beginning. It ratified the Kyoto Protocol in 2002, but in spite of the huge potential on emission reductions, it took the country a long time to gain significant participation in the CDM [32]. China took an early adoption of the CDM, in particular by establishing the National CDM Board under the Chinese National Coordination Committee on Climate Change (NCCCC) in October 2005. The Board consists of seven ministries and is in charge of regulations and procedures for the operation of the CDM in the country. To make the process faster, China invested in regional facilities to better coordinate with CDM and included climate mitigation policies as part of its national strategy, which helps to reduce transaction costs and attract investors. Another reason for China's success is its ability to attract many investors, which they can achieve because they are the "land of opportunity" regarding CO_2 emissions and they have the means to be attractive for investments [33,34].

In the case of India, their Ministry of environmental and forest, established a National Clean Developed Mechanism Authority for promoting CDM projects. The Government actively works on the promotion and implementation of renewable energy and serves as an important member to promote CDM and reduce the critical impacts of climate change [7].

3. CDM in Latin America

3.1. Registered projects and performance of different countries in the region

As of December 2012, a total of 668 CDM projects were registered in Latin America, issuing a total of 128,155.51 kCERs, from which 376 projects generate electricity with a capacity of 11,431.76 MW. The region is second in the world in terms of number of projects, issued CERs, and projects generating electricity. It is the first region where all of the eligible countries have hosted a CDM project. The strongest countries are Brazil, Mexico and Chile. Brazil has 34% of all the projects and 36% of the ones generating electricity, Mexico 22% of all the projects and 19% of the ones generating electricity, and Chile 9% of all the projects and 12% of the ones generating electricity. Of all the CERs issued in Latin America, 59% of them are from Brazil, 14% from Mexico, and 8% from Chile (see Fig. 4). By the end of 2012, Brazil was emitting credits at a rate of more than twice the rest of Latin America combined.

Of the total registered capacity of energy projects, 93% are renewable energy project, 5% are methane reductions projects and 2% are energy efficiency from the supply side (industrial cogeneration based on gas). Table 4 presents the biggest projects for each of these categories.

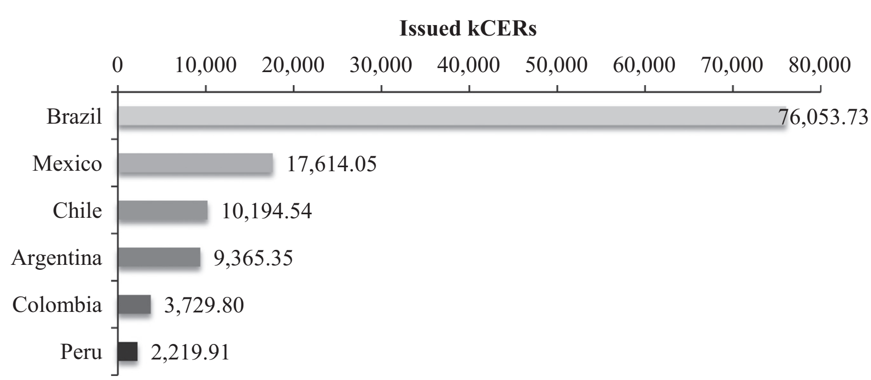

Fig. 4. Issued kCERs from Latin America's top 6 countries.
Source: [28,29].

Table 4
Biggest projects (in MW) with registered capacity under each category in Latin America.
Source: [28,29]

Type of project	Most common subtype	Biggest associated project	Description
Energy efficiency – supply side	Own Generation projects	Generation of Electrical Energy in SOL Coqueria by Process Heat Recovery – Brazil	With 149 MW and consists on the generation of electricity from heat recovered from the production of coke
Methane reduction	Landfills	Bandeirantes Landfill Gas to Energy Project – Brazil	With 120 MW, consists of using the methane from a mine, usually discharged to the atmosphere, for the generation of electricity, connected to the grid
Energy efficiency – demand side	Industries	Petrotemex Energy Integration Project – Mexico	With 36.20 MW it consists on a series of mitigation measures to reduce CO_2 through fuel and electricity savings

Table 5
Top 10 biggest projects (in MW) in renewable energy in Latin America.
Source: [28,29].

Title	Country	Type	Registered capacity (MW)	% From total renewable energy capacity ()
Eurus Wind Farm	Mexico	Wind	249.00	2.35
Fundão-Santa Clara Energetic Complex Project	Brazil	Hydro	246.10	2.32
Ckani Wind Farm Project	Chile	Wind	240.00	2.27
El Platanal Hydropower Plant	Peru	Hydro	220.00	2.08
Istmeño Wind Farm	Mexico	Wind	215.65	2.04
Bii Nee Stipa	Mexico	Wind	200.00	1.89
Electricity generation from renewable sources-Windfarms Santa Clara I, Santa Clara II, Santa Clara III, Santa Clara IV, Santa Clara V, Santa Clara VI and Eurus VI	Brazil	Wind	188.00	1.78
Cheves Hydro Power Project, Peru	Peru	Hydro	168.00	1.59
Bii Nee Stipa III	Mexico	Wind	164.00	1.55
Bii Stinu Wind Energy Project	Mexico	Wind	164.00	1.55%
Total			**2054.75**	**19.39**

3.2. Renewable energy in Latin America

From the 11,431.76 MW of registered projects in Latin America, 10,582.37 MW (93%) corresponds to renewable energies, making a clear majority over methane reductions (5%) and energy efficiency from the supply side projects (2%). Brazil has the most with 36% of renewable energy projects, followed by Mexico with 19%, and Chile with 13%. Hydro energy projects represent 47% of the total capacity in renewable energy projects for the region, with a total registered capacity of 4959.58 MW. Brazil has the most hydro, with 43% of this capacity, followed by Peru with 18%. There are 3870.75 MW of wind energy projects in the region representing 37% of all renewable capacity. Mexico has the most with 52% of this capacity. Finally, there are 1551.64 MW of biomass projects in the region, accounting for 15% of the renewable energy capacity. Brazil has the most biomass projects, representing 61% of projects. Table 5 provides an overview of the 10 biggest projects in the region, all of them are either wind or hydro energy projects. Interestingly, only 10 projects out of a total of 305 in renewable energy projects constitute almost 20% of the entire capacity.

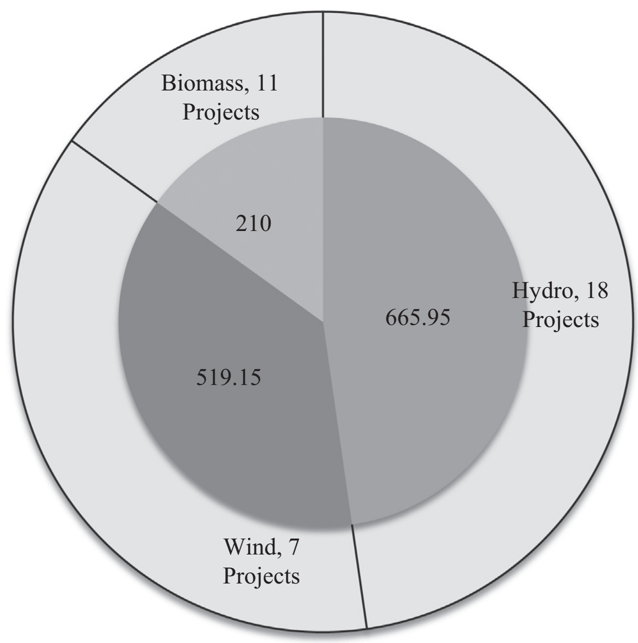

Fig. 5. Distribution of capacity (total = 1395.10 MW) across renewable energy projects. *Source*: [28,29].

4. The CDM portfolio in Chile

Up until December 2012, 62 projects were registered in Chile, issuing a total of 10,194.54 kCERs, from which 37 projects generate electricity representing a capacity of 1411.64 MW. From these projects, 99% of the registered generating capacity is renewable energy projects with the other 1% corresponding to methane reduction and energy efficiency from the supply side projects. The rest of the projects in Chile, such as reductions of N_2O and HFC or energy efficiency from the demand side projects, among others, only focus on reducing emissions as opposed to generating electricity.

There are 20 registered methane reduction projects and the majority of those are landfill projects, in which the methane produced by the projects is either captured and destroyed, injected through piping systems back to the plant for thermal purposes, or flared for electricity generation. Only 3 of the projects generate electricity, in which "Loma Los Colorados Landfill Gas Project" is the biggest with 10 MW. There is only one Energy Efficiency from the supply side project: "Metrogas Watts's Package Cogeneration Project", that has a capacity of 2.94 MW and consists in a cogeneration system that consumes natural gas and sells electricity and heat to an industrial plant.

There are 36 renewable energy projects totaling 1395.10 MW of registered capacity. Hydro energy accounts for nearly half of the total renewable energy projects, representing 48% of the registered capacity and 50% of renewable projects, while wind and biomass represent the other half. Wind energy projects make up with 37% of capacity and 31% of the projects and biomass projects make up 15% of capacity and 19% of renewable energy projects (see Fig. 5).

From the 1411.64 MW of registered capacity in Chile, 970.75 MW (69%) corresponds to installed capacity in already operating projects. Renewable energy accounts for 99% of this and the one methane reduction project ("Loma Los Colorados Landfill Gas Projects") for 1%. Amongst the renewable energy projects, hydro projects are the majority, with 649.62 MW (68%), followed by wind projects with 176.93 MW (18%) and last biomass with 131.90 MW (14%). The biggest operational CDM project producing electricity is "Project for the reduction of greenhouse gas emissions of Hidroelectrica La Confluencia S.A.", a hydroelectric project of 164.65 MW.

In Chile, a total of 10,194.54 kCERs were issued during the first commitment period, with the projects distributed under three types: methane reductions, HFC and N_2O reductions, and renewable energy. Almost half of the issued CERs belong to methane reduction projects (48%). In fact, the combined credits from 2 of these projects: "Methane capture and combustion from swine

manure treatment for Pocillas and La Estrella" and "Loma Los Colorados Landfill Gas Project" are higher than the generated CERs from all 9 renewable energy projects with issued CERs. Indeed, even if only two HFC and N_2O projects are registered and have produced carbon credits, they correspond to 30% of the total issued CERs in Chile, while renewable energy accounts for 22%, in spite of representing the majority of the CDM projects in the country. These results match the discussions of Ellis et al. [8] and Nussbaumer [21] for end-of-pipe projects. Both methane reductions and HFC and N_2O reduction projects have high global warming potentials (respectively with 21 CO_2e, between 140–11,700 CO_2e and 310 CO_2e) and require low investments, thus representing low cost GHG reductions in comparison to more capital-intensive energy technology options such as renewable energies, and at the same time are able to generate much more CERs than the latter. For example if comparing 13 methane reduction projects against the same amount of renewable energy projects (hydro, wind and biomass), methane reduction projects imply an investment of 5.533 US/kCER while renewable energy projects involve an investment of 48 times more (267.739 US/kCER).

Methane reductions and HFC and N_2O reduction projects are usually brownfield sites (land previously used for industrial processes or otherwise developed and often polluted), so it is fairly easy for project developers to prove that in absence of the projects there are no incentives to reduce emissions from current levels. These types of projects carry almost no sustainable development benefits, and furthermore, their high potential of delivering low cost GHG reductions could trigger negative effects for the overall CDM in terms of sustainable development. The fact that Chile has more renewable energy projects in its pipeline than other "easier" technologies shows that the country is not only interested in gaining credits, but also really concerned with growing and expanding their energy matrix in a sustainable manner. Table 6 provides detailed information for the number of projects, capacity and issued CERs for each type of CDM project in Chile.

There is significant variation in the distribution of projects in Chile throughout the different regions, mainly concentrating in central Chile. From 15 regions, 5 of them do not have any CDM projects. For the highest grossing CDM project types, HFC and N_2O

Table 6
Number of projects, registered capacity and issued CERs for CDM projects in Chile grouped by type.
Source: [28,29].

Type	No. of projects	%	MWe	%	Issued kCERs	%
Renewable energy	36	58	1395.10	99	2208.25	22
Methane reductions	20	32	13.60	1	4867.02	48
HFC and N_2O reductions	2	3	0.00	0	3082.69	30
Sinks	2	3	0.00	0	0	0
Energy Efficiency – Supply	1	2	2.94	0	0	0
Fuel switch	1	2	0.00	0	36.58	0
Total	**62**	100	**1411.64**	**100**	10,194.54	100

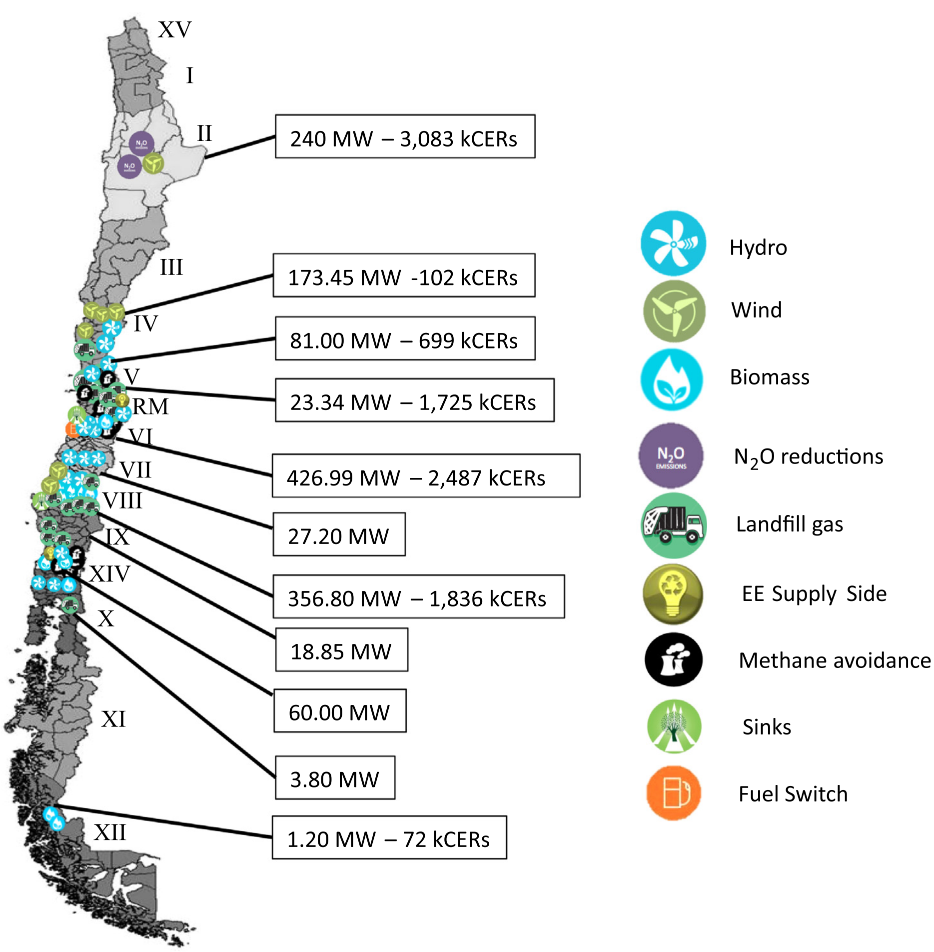

Fig. 6. Map of Chile according to regions, for registered capacity, issued CERs and concentration of projects expressed by dots.
Source: [28,29].

projects are located in the north (Region II), due to the fact that nitrate salts are located in large deposits in the saltpeter in the north of Chile, whilst methane reduction projects are mostly distributed in the center of the country, corresponding with the highest concentration of industries and population (RM, V, and VI Regions). On the other hand, renewable energy projects are distributed throughout the regions. 26% of renewable energy projects belong to the south (Region VIII), with the majority corresponding to biomass due to the location of many sawmills in the region. The south regions (VIII, IX and X Regions) of the country attract most of the hydro projects for their many water resources; meanwhile the north of the country (IV Region) attracts the mainstream of wind projects (see Fig. 6).

5. Additionality of renewable energy CDM projects in Latin America

In order to assess the transparency and accountability behind the claims made in the Project Design Documents (PDDs), particularly about the barriers stated as the reasons impeding the development of the projects, a study analyzing the quantitative and qualitative data provided by project developers to register their projects is presented in this section.

5.1. Objective of the study

Following the evaluation of the portfolio of CDM projects in Latin America and specially in Chile, one of the main findings is the strong participation of renewable energies, often associated with higher sustainable development benefits [21], in particular of wind, hydro and biomass projects, despite the fact that they cost more than other technologies that provide more carbon credits. Furthermore, renewable energy projects are often faced with more uncertainties and implementation barriers. This is why a study summarizing the most common arguments provided in the additionality assessment is pertinent to this article in order to understand how renewable energy projects actually perform.

5.2. Renewable energy project data set

The information for the analysis is obtained through the UNFCCC website [35], manually for each PDD, project by project. PDDs contain all information for each project regarding its barriers for implementation and economic information for the costs implicated in the project, thus being the most suitable source of information. Since thorough review of each PDD and supplementary information (cash flows, validation report, monitoring report, etc.) takes a considerable amount of time, the project data set was filtered following a series of criteria to ensure all countries with renewable energy projects are represented and that hydro, wind, and biomass technologies are included.

Only countries with at least one renewable energy project are considered, for these, if the country has less than 8 projects, all of them are included in the sample. For countries with more than 8 projects such as Brazil, Mexico and Argentina, 20% of all the projects in the country are considered randomly. Finally, since Chile is the main focus of the analysis, all projects for this country are considered. This leads to a sample of 180 projects from 18 countries.

5.3. Methodology applied

The methodology consisted of reading all PDDs and supplementary information available at the UNFCCC website for the selected projects [35]. This includes cash flows, validation reports, monitoring reports, wind studies when available, emission factor calculations, etc. From this information the investment analysis, barriers analysis and common practice analysis are extracted. The information is analyzed and separated into quantitative and qualitative analysis. The quantitative analysis provides average values for benchmarking internal rate of return (IRR), project IRR, investment costs, capacity, and investment associated with electricity generation, capacity factor and emission factor. The qualitative analysis provides a review of the most common arguments associated with barriers faced by the different types of projects and their proof of not being the common practice.

5.4. Main findings: barrier analysis lacks transparency and is preferred over the investment analysis

The barrier analysis, in which the project developer needs to prove that the project faces more barriers than a reference case (alternative to the project) or that the CDM allows the project to overcome certain barriers, seems to be preferred over the investment analysis for registering projects. In the latter the project developer needs to prove that the project either faces more costs than an alternative or is less profitable than a reference case or a benchmark. The common practice analysis, where the project developer must prove that the project is not a common practice, meaning that if other similar projects are already operating, they should either face a very different economic situation or they should also be receiving incomes from the CDM, mostly accompanies either the investment or barrier analysis, but it is never presented on its own so it will not be examined any further.

The benchmark IRR marks the baseline to which the project's IRR is compared. If the project is more profitable than the benchmark, then it is not considered additional and therefore cannot be

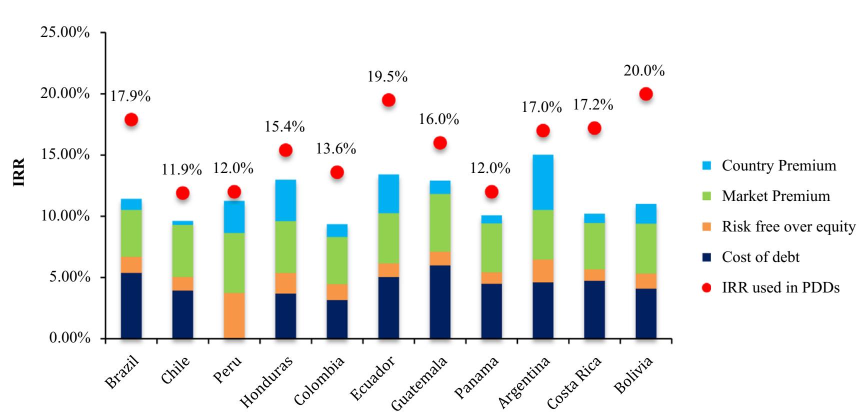

Fig. 7. Benchmark decomposition for hydro projects and average benchmark used in the PDDs.

registered into the CDM. However, as no guidelines exist to determine the IRR to be used as a benchmark, frequently project developers use the benchmark that most suits their projects.

In this study, in order to set a common base for analysis, benchmarks are calculated for each country using the Weighted Average Cost of Capital (WACC), which is considered the most comprehensive method because it considers the specific risk associated with each country [35]. The WACC's calculation is based in market standard parameters, taking into account project-specific characteristics and it is not linked to the subjective profitability expectation or risk profile of any particular project developer. The WACC is calculated according to formula 1.

$$\mathrm{WACC} = E/Ck_e + D/Ck_d \tag{1}$$

From which E is the equity, C the capital as total firm value, D the Debt, k_e the cost of equity, and k_d the cost of debt.

The cost of equity, k_e, estimated according to the Capital Asset Pricing Model (CAPM):

$$k_e = R_f + \mathrm{Beta}\ R_m + R_c \tag{2}$$

From which R_f is the risk-free rate, R_c the country risk, R_m the market risk premium, and Beta the risk measure comparing the returns of the asset to the market over a period of time.

The expression is as follows:

$$\mathrm{WACC} = W_e(R_f + \mathrm{Beta}\ R_m + R_c) + W_d k_d$$

Or alternatively,

$$\mathrm{WACC} = W_e R_f + W_e\ \mathrm{Beta}\ R_m + W_e R_c + W_d k_d$$

This can be decomposed for exposition purposes as follows:

$$\mathrm{WACC} = \text{Risk free component} + \text{Market risk premium component}$$
$$+ \text{Country risk component} + \text{Cost of debt component}$$

with W_e: E/C, the weight of equity; W_d: D/C, weight of debt.

The parameters for the calculation including the risk-free rate, beta, country risk and market risk premium are obtained through Damodaran's website [37], while the weight of equity and debt are obtained as an average of the available values used in the sample of studied PDDs for hydro, wind and biomass projects, respectively. Finally for the cost of debt several sources are utilized, such as the PPDs, value of the average government bond or the average between the rest of the technologies available in the country in question, or if none of the above are available, in countries with the same debt classification.

When calculating the benchmarks with the Weighted Average Cost of Capital (WACC) model, most of the benchmarks used in the PDDs are higher than the WACC calculated here. This may imply that project developers are in fact evaluating their projects against impossibly high benchmarks which do not reflect the true environment that the project will face. The values used are often so high that the registration under the CDM is not questionable, however they also hurt their possibilities for attracting foreign investors, which does not help to promote technology transfer and other types of sustainable development benefits.

Among the factors that constitute the IRR, the one that varies the most is the country risk premium component (country risk times the weight of equity of the project), in which Argentina

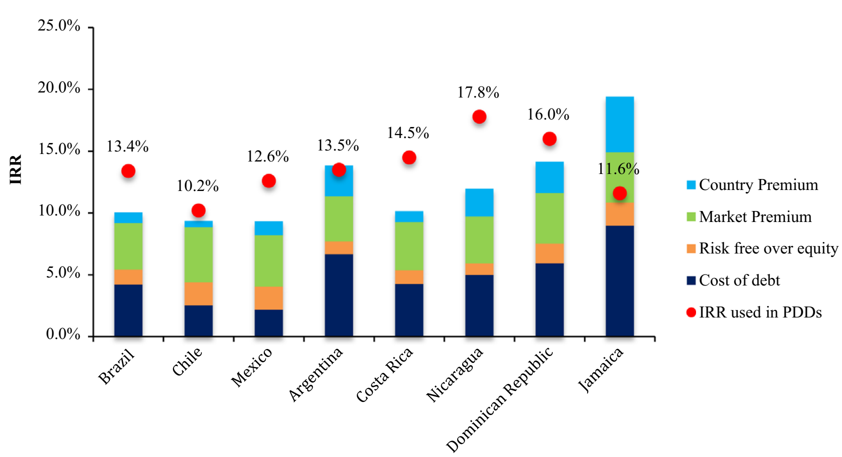

Fig. 8. Benchmark decomposition for wind projects and average benchmark used in the PDDs.

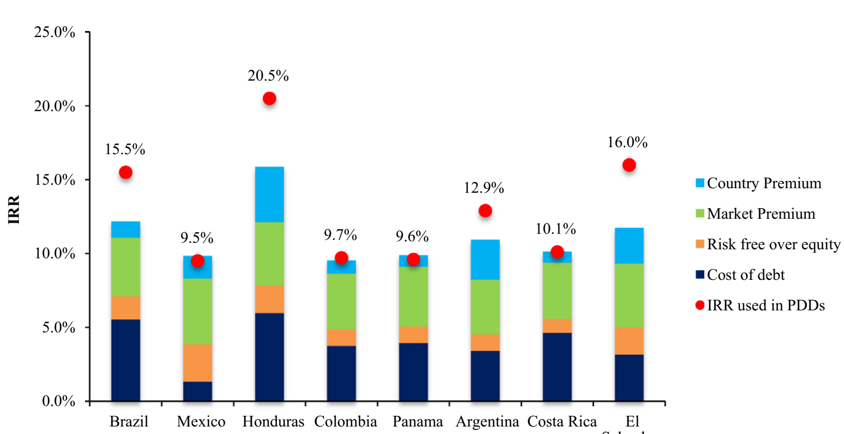

Fig. 9. Benchmark decomposition for biomass projects and average benchmark used in the PDDs.

presents the highest risk for hydro projects, Jamaica for wind projects and Honduras for biomass projects. Figs. 7–9 present the decomposition of the calculated benchmarks IRR for hydro, wind and biomass projects compared to the ones used by project developers on the PDDs.

Considering hydro projects (see Table 7) the *IRR benchmark* used as comparison baseline corresponds on average to 15.7%, while the *projects' IRR*, representing the profitability of the project activity, is 12.7% on average. Selling CERs increases the projects' IRR by 2.1 percentage points, reaching a 14.2%. The capacity factor for hydro projects in Latin America is 57% and the investment per unit of capacity reaches 1963 US$/kW (ranging from 1161 US$/kW in Argentina to 3025 US$/kW in Panama), while the investment per unit of electric energy corresponds to 54.5 US$/GWh as an average in hydro projects in Latin America.

The reasons for some countries presenting higher costs of investment for hydro projects are many times related to how much hydro energy is already present in their energy matrix compared to how many resources are available. The most cost-effective hydro projects are usually already exploited and thus current CDM projects require higher investments to exploit hydro resources. For example, Panama has a very low hydro potential of 3282 MW with 34% of it already installed (1106 MW), while Argentina has a potential of 40,400 MW, with 25% of it installed (9934 MW), indicating that there are still plenty of hydro resources left to develop in these countries. Mexico is a special case, because even though it is the second most expensive

Table 7
Summary on IRR investment analysis in Latin America for CDM hydro energy projects.
Source: [28,29].

Category	Average benchmark IRR (%)	Average projects' IRR (%)	Average Δ project IRR: with CERs–without CERs (%)	Average total investment (MUS$)	Average capacity (MW)	Average investment/capacity (US $/kW)	Average capacity factor	Average investment per unit of electric energy (kUS$/GWh)	Average emission factor (tCO_2e/MWh)
Brazil	17.9	11.9	1.4	43.92	36.1	1216	56%	57.7	0.36
Chile	11.9	8.3	2.5	80.61	40.0	2080	59%	44.9	0.54
Peru	12.0	12.0	2.2	62.92	50.9	1237	67%	57.7	0.46
Mexico	N/A	N/A	N/A	45.00	17.5	2577	50%	28.2	0.46
Honduras	15.4	N/A	1.0	14.67	8.6	1708	58%	51.0	0.62
Colombia	13.6	12.7	1.6	46.05	19.2	2398	68%	32.2	0.37
Ecuador	19.5	17.0	1.0	24.60	17.3	1420	72%	21.6	0.66
Guatemala	16.0	11.5	1.6	81.07	42.2	1922	48%	46.4	0.68
Panamá	12.0	10.0	0.8	96.91	32.0	3025	68%	66.7	0.55
Argentina	17.0	11.0	6.2	145.36	125.2	1161	64%	24.1	0.50
Costa Rica	17.2	14.9	N/A	74.94	32.3	2320	45%	140.1	0.23
Uruguay	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nicaragua	N/A	N/A	N/A	N/A	1.9	N/A	57%	N/A	0.63
El Salvador	N/A	N/A	N/A	163.30	65.4	2497	40%	83.5	0.63
Dominican Republic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Jamaica	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bolivia	20.0	17.5	2.5	N/A	89.5	N/A	39%	N/A	0.61
Guyana	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	**15.7**	**12.7**	**2.1**	**73.28**	**40.2**	**1963**	**57%**	**54.5**	**0.52**

Table 8
Summary on IRR Investment Analysis in Latin America for CDM wind energy projects.
Source: [28,29]

Category	Average Benchmark IRR (%)	Average IRR within projects (%)	Average Δ Project IRR: with CERs – Without CERs (%)	Average Total Investment (MUS$)	Average Capacity (MW)	Average Investment/capacity (US $/kW)	Average capacity factor	Average investment in electricity (kUS $/GWh)	Average emission factor (tCO_2e/MWh)
Brazil	13.4	4.8	0.5	127.02	64.9	1957	40%	34.2	0.42
Chile	10.2	5.2	1.4	178.65	74.2	2292	29%	136.6	0.64
Peru	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mexico	12.6	9.4	1.7	286.53	154.0	1860	46%	55.9	0.56
Honduras	N/A	N/A	N/A	N/A	102.0	N/A	39%	N/A	0.66
Colombia	N/A	N/A	N/A	21.00	19.5	1077	34%	42.7	0.44
Ecuador	N/A	N/A	N/A	12.65	4.9	2556	16%	352.1	0.86
Guatemala	N/A	N/A	N/A	N/A	48.0	N/A	29%	N/A	0.73
Panamá	N/A	N/A	N/A	N/A	81.0	N/A	37%	N/A	0.66
Argentina	13.5	6.9	2.1	16.09	8.4	1909	40%	76.6	0.59
Costa Rica	14.5	8.3	N/A	48.97	27.4	1790	45%	64.3	0.31
Uruguay	N/A	N/A	N/A	29.70	11.7	2532	34%	89.5	0.62
Nicaragua	17.8	15.7	2.6	78.15	35.7	2191	46%	61.7	0.70
El Salvador	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dominican Republic	16.0	10.1	1.7	53.47	32.2	1663	30%	56.1	0.73
Jamaica	11.6	10.5	1.3	33.80	19.4	1747	35%	69.4	0.78
Bolivia	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Guyana	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	**13.7**	**8.9**	**1.6**	**80.55**	**48.8**	**1961**	**36%**	**94.5**	**0.62**

country, out of its 53,000 MW potential, only 22% (11,619 MW by 2005) of its electricity matrix corresponds to hydro energy [38]; so plenty of resources should still be available; however, renewable energies do not occupy a large percentage of the matrix since the country's internal policies favor carbon intensive energies for their lower cost [29].

In the case of wind projects (see Table 8), the *IRR benchmark* corresponds on average to 13.7%, while the *projects' IRR* is 8.9% on average. In this kind of projects, the CERs impact is lower than for hydro projects, only increasing the IRR on 1.6 percentage points, reaching a 10.5%. This means that while hydro projects may be considered riskier than wind projects and thus face higher benchmarks, they are still more profitable and obtain higher benefits from CDM. On the other hand, the capacity factor for wind projects (36%) is much lower than for hydro projects, while the investment per unit of capacity for wind is quite similar to that of hydro, averaging 1961 US$/kW (ranging from 1077 US$/kW in Colombia to 2556 US$/kW in Ecuador), but per unit of electric energy it is 94.5 US$/GWh, a 58% higher than hydro projects.

Finally, for biomass projects (see Table 9), the *IRR benchmark* corresponds on average to 12.9%, while the *projects*' *IRR* is 9.9% on average. In these kinds of projects, the CERs impact is the highest for the three types of technologies, increasing the IRR by 12.3 percentage points, reaching a 22.2%. Their capacity factor is similar to hydro projects (57%), while the investment costs per unit of capacity and per unit of electric energy are the lowest of the studied renewable energies, with 908 US$/kW (ranging from 318 US$/kW in El Salvador to 1804 US$/kW in Chile), and 28.2 US $/GWh, respectively, which is often due to the fact that many biomass projects consist in cogeneration projects implemented in already existing plants, so the infrastructure's costs are lower.

A sensitivity analysis on the factors affecting the IRR (varying +10% of them) reveals that the access to the resource: water, wind or type of biomass (plant factor), the energy market (electricity price) and the type of technology used (investment) are the three key parameters determining the profitability of a renewable energy project in Latin America (see Table 10).

Regarding the qualitative analysis, for hydro projects the most commonly faced barriers have to do first with an investment barrier due to the fact that most investors want projects with attractive IRRs or short payback periods, neither of which can be delivered by these projects. Technological barriers also exist, including lack of water availability, especially for run-of-river projects because these projects do not have reservoirs, so in case of draught the plant has to stop. Other barriers include regulatory risks, such as limited access to water rights or other permits and adverse political climate when the project is to be installed in a controversial location.

For wind projects, besides investment or regulatory risks like hydropower, access to the technology can also be a significant barrier because much of the equipment must be imported, which increases costs. Other barriers include the lack of skilled personnel for operating the equipment, and the economic situation of the country, which many times provides no incentives for these types of projects.

For biomass projects, the fact that biomass and specifically cogeneration is fairly new may be an obstacle because there are not many similar projects nearby, which creates cultural and technical know-how barriers. Most of the projects use different types of biomass to feed the cogeneration system, which means that even if many biomass projects exist in one country, they may all be different and face different conditions. Biomass is also restricted by the availability of crops and forests nearby.

5.5. Discussions on findings

When comparing investment analysis (quantitative) with barriers analysis (qualitative), there is a tendency for project developers to prefer the latter when appling for registration in the CDM. From the

Table 10
Sensitivity analysis on drivers affecting the IRR in Latin America.

Average for Latin America	Δ IRR +10% plant factor (%)	Δ IRR +10% electricity price (%)	Δ IRR +10% investment (%)	Δ IRR +10% total costs (%)	Δ IRR +10% capacity price
Hydro	+2.24	+1.25	−1.05	−0.30	+0.17%
Wind	+3.15	+1.35	−1.14	−0.30	+0.11%
Biomass	+2.74	+2.17	−1.30	−1.08	N/A
Total	**+2.71**	**+1.59**	**−1.16**	**−0.56**	**+0.14%**

Table 9
Summary on IRR Investment Analysis in Latin America for CDM biomass energy projects.
Source: [28,29].

Category	Average benchmark IRR (%)	Average IRR within projects (%)	Average Δ project IRR: with CERs–Without CERs (%)	Average total investment (MUS$)	Average capacity (MW)	Average investment/capacity (US $/kW)	Average capacity factor	Average investment in electricity (kUS $/GWh)	Average emission factor (tCO_2e/MWh)
Brazil	15.5	10.5	4.2	21.18	25.7	1167	59%	22.3	0.41
Chile	N/A	9.4	N/A	11.34	26.4	1804	82%	23.3	0.87
Peru	N/A	N/A	N/A	1.46	0	N/A	N/A	N/A	N/A
Mexico	9.5	1.7	12.7	7.85	0	N/A	N/A	N/A	N/A
Honduras	20.5	12.9	N/A	4.43	9.9	343	26%	20.8	0.77
Colombia	9.7	−0.1	43.1	1.45	0	N/A	N/A	N/A	N/A
Ecuador	N/A	9.0	6.0	N/A	31.3	N/A	12%	N/A	N/A
Guatemala	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Panamá	9.6	3.5	11.6	2.14	0	N/A	N/A	N/A	N/A
Argentina	12.9	6.4	5.7	2.14	0	N/A	56%	18.2	0.46
Costa Rica	10.1	32.2	18.9	4.02	0	N/A	N/A	N/A	N/A
Uruguay	N/A	N/A	6.8	N/A	16.5	N/A	64%	N/A	0.8
Nicaragua	N/A	N/A	N/A	N/A	64.5	N/A	N/A	N/A	N/A
El Salvador	16.0	13.6	1.9	12.19	39.3	318	N/A	N/A	N/A
Dominican Republic	N/A	N/A	N/A	N/A	0.7	N/A	82%	N/A	0.62
Jamaica	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bolivia	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Guyana	N/A	N/A	N/A	32.2	10.0	N/A	77%	56.1	0.66
Total	**12.9**	**9.9**	**12.3**	**9.13**	**14.9**	**908**	**57%**	**28.1**	**0.66**

sample analyzed here, 74% of hydro projects, 60% of wind projects and 98% of biomass projects performed a barriers analysis, while 45% of hydro, 62% of wind and 34% of biomass performed an IRR benchmark investment analysis. The quantitative analysis is much more regulated by the UNFCCC than the qualitative analysis, because countries only need to make a list of barriers, without any proof of the existence of such barriers. On the other hand, for the investment analysis a clear demonstration that the project is not viable without the income of CERs has to be provided in order to accept the project as additional. This exercise may prove more difficult. For the barrier analysis, the project developers usually use very general statements about the key barriers and many times do not provide any explanation on how the CDM will help to overcome these barriers. In several occasions "investment barriers" are declared, with no indication of costs or their magnitude or impact on revenue from the project and almost all projects claim that "prevailing practices", such as fossil-fuel generation, are a barrier.

Overall the problem is that the barrier analysis is too subjective, hindering the validation of the project and its transparency. In a study performed by Schneider [39], it was found that only 6% of the validation reports contain a detailed assessment of each barrier, so most of the times the barriers are just accepted as such with no more requests made to register the project. Moreover, since most investments in any type of project would face barriers and often the same barriers as those stated, it is difficult to distinguish between additional and non-additional projects [36,40–41].

The investment analysis is not exempt from criticism either, the main one being the varying quality of the analysis. While many PDDs in the study provide a detailed explanation on the assumptions made for the analysis, others only provide the general values, not explaining where they come from.

No methodology for sustainable development assessment at a global level exists in the CDM. The host country is responsible for determining whether the project assists in achieving sustainable development or not. This carries a risk of having different countries competing in order to attract CDM investments by taking the requirements to minimum levels. The decision to accept a project may be influenced by national priorities or interests of strong stakeholders, and the host country needs to balance the short-term benefits of foreign investment and the long-term benefits of sustainable development, which has led to the portfolio being mainly driven by the economic attractiveness of the project. This situation is exacerbated by the fact that technologies associated with higher sustainable benefits, like renewable energy, which have the potential provide reliable energy services while reducing GHG emissions, are also the most expensive. Renewable energy can help mitigate geopolitical concerns and energy price volatility, and at the same time provide a basis for technology innovation [19,21,42,43].

To promote renewable energy, it is necessary to enhance networking and cooperation among countries, to facilitate information dissemination of the best practices in the area, to share experience and to help build capacities in this field [44]; however none of this facts are evaluated regarding sustainable development, nor are they included in the stated barriers towards the development of these technologies, showing just how further from the state it needs to be to endorse renewable energies the CDM is.

In conclusion, there is too much vagueness in the CDM registry process, which makes it very difficult to separate projects that really need CDM and contribute to both emission reductions and sustainable development, from those only seeking CDM to increase their profits but may not need CDM support to proceed. It is critical to establish more regulation that can guarantee a project's additionality. Even the renewable energy projects studied here, supposedly associated with the highest sustainable development benefits, lack a detailed and transparent assessment of their additionality, underscoring the need for more regulation.

6. Recommendations and conclusions

CDM has been the main effort under the Kyoto Protocol to involve developing countries in reducing GHGs emissions and to provide flexibility for developed countries to reach their emission reduction targets at low costs. While CDM projects had a slow beginning, around 2010 the mechanism gained momentum. Within 5 years, up until the Conference of the Parties in Doha, the CDM registered 5193 projects worldwide, issuing a total of 1,115,241 kCERs, distributed among 81 countries. Most projects correspond to renewable energy developments exploiting hydro, wind and biomass (71%).

The distribution of projects is very unequal amongst regions, with the majority of them concentrated in Asia & Pacific (86%) and in Latin America (11%), whereas the Sub-Saharan countries have not seen CDM benefits because they lack the capacity and institutions to be attractive to investors. Countries like China, India and Brazil, with the highest levels of FDI confidence indexes and GHG emission levels (which allow them to reduce emissions at lower costs) have developed the majority of the projects.

CDM has a great potential to promote sustainable development while reducing GHG emissions in developing countries, promoting low emission alternatives at the supply side, energy efficiency at the demand side, as well as more sustainable options in the transportation, forest and agricultural sectors.

In energy supply, CDM can provide additional incentives for promoting renewable energy since carbon credits can help the financial attractiveness of a project. Nonetheless, in order to increase the participation of renewable energy, continued innovation is needed by developing and enhancing existing technologies and fostering mass implementation, so that benefits from economies of scale are attained and costs that often remain high compared to fossil fuels can be decreased. It is also important to integrate them into the host countries energy systems by establishing policy frameworks to promote them, temporary subsidies or fiscal schemes [45,5] to allow them to overcome the initial barriers they have to face [46].

CDM represents a huge potential to promote sustainably development in developing countries. Renewable energy offer greater sustainable development benefits in that they offer clean energy generation, contribute to energy independence and security, and often create employment opportunities. However, analyzing the implementation of the CDM program over the first commitment period reveals that there has been a biases in favor of low cost emission reductions over sustainable development [47]. The main reason the program has not reached its sustainable development objective lies in the fact that the assessment process used to award CERs is too subjective, depends heavily on decentralized standards on sustainable development that vary from country to country, and lacks rigorous and standard evaluation process overseen by the United Nation. The assessment of sustainable development has been left to each country's sovereignty, which has resulted in competition between host countries to gain CDM projects by lowering their sustainable development requirements. National authorities are faced many times with the decision between short-term benefits of CDM incomes against long-term benefits of sustainable development.

A more in depth study of Chile reveals the complexity of CDM implementation challenge. In Chile most projects are renewable energy projects (36 out of 62). However, the majority of the issued CERs are from methane reduction projects (48%), followed by a 30% from HFC and N_2O reduction projects and only in third place renewable energies with 22% of the total generated CERs. In fact, only 2 methane reduction projects account for more than the issued CERs from 9 renewable energy projects. This constitutes a problem at a global level, since some types of projects like CH_4 and

HFC and N_2O reductions, by having higher global warming potential, can save more emissions and because these projects are usually implemented at brownfield sites, the projects represent lower costs. Even if they can issue many more CERs than renewable energies, they represent very meager sustainable development benefits. The main driver of the CDM portfolio during the first commitment period has been emission reductions at lowest cost, leaving behind the sustainable development objective of the CDM.

From sample of PDDs studied, it is clear that the investment analyses differ in quality from country to country and from project to project, with some PDDs providing detailed information for every calculation whilst others just provide the general numbers, making verification extremely difficult. The barrier analysis is even less standardized, with many projects citing unclear barriers or not explaining how the CDM benefit will help overcome those barriers. Moreover, almost no verification process exists for validating barriers, so in the end it is very difficult to differentiate between a non-additional or an additional project, which in many cases means that a non-additional project has been registered as additional.

The Conference of the Parties held in Doha in 2013, which coincided with the start of the second commitment period of the Kyoto Protocol and the CDM, did not make any relevant changes to the CDM from the previous model. However, an agreement was reached to deliver the successor to the Kyoto Protocol in 2015. This document needs to make radical changes to the CDM and the additionality assessment since it is the main effort intended to help the developing nations execute real sustainable development. For this reason, it is essential for additionality to be quantifiable and verifiable.

From one perspective, the CDM program has proven to be a successful mechanism for driving emissions reduction at the lowest cost. In today's environment, with more and more tangible evidence of the negative effects of climate change, one could argue that large scale, low-cost emissions reduction should be the priority. However, fostering sustainable development among developing countries is crucial to ensuring the long-term benefits and continuity of GHG emission reductions that enables economic and social development. It is this later aspect of the CDM program that has been underachieving.

The main change needed is for increased clarification and regulation of the requirements for a project to be registered under the CDM. For example a benchmark IRR should be set for each technology in every country, instead of letting every project developer use the one that most benefits his or her project. It should not be possible for projects of similar characteristics located in the same countries and areas to be tested against completely different benchmarks.

It is also a questionable to allow projects to be registered years after they are implemented, because if they need to prove that they could not exist without CDM benefits, then they should not be already operating. The barrier analysis and sustainable development benefits should be tested against set criteria, and verifiable proof should be provided. An international standard for sustainable development should be imposed and followed by every country, so at least a baseline of requirements is set. In many cases a more detailed analysis should be provided to show how CDM would help the project to be executed. Finally, an exception should be made in favor of the least developed countries, which have been unable to participate in the CDM, and for them in particular the rules for registering projects should be simplified and international aid provided so they can develop the necessary institutions to promote CDM. These changes, if implemented will help the next version of the Kyoto Protocol support sustainable development in developing nations as the CDM program originally intended, contributing to long-term economic developed that is decoupled from ever increasing greenhouse gas emissions.

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